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LIQUID CRYSTAL DISPLAY DEVICE

[Detailed Description of the Invention]

[0001]

[Field of the Invention]

The present invention relates to a liquid crystal display device, and more specifically to an active matrix type liquid crystal display device using a thin film transistor as a switching element.

[0002]

[Related Art]

Liquid crystal display devices are advantageous in that they are thin and light-weight, can be driven by a low voltage, can achieve color display easily, or the like, and have recently been used as display devices for personal computers, word processors, or the like. In particular, active matrix liquid crystal display devices which use an amorphous silicon thin film transistor (a-Si TFT) as a switching element are being expected as a full-color television or a display device for office automation because these devices do not suffer from degradation of contrast, response or the like even with the increased number of pixels and also because they can achieve halftone display.

[0003]

Fig. 6 shows a view schematically showing a structure of a conventional active matrix liquid crystal display device using an a-Si TFT.

[0004]

In Fig. 6, numeral 81 denotes a pixel electrode, which is connected to a source electrode 78 of a TFT. Further, an opposing electrode 83 is provided on the pixel electrode 81 via a liquid crystal layer 82.

[0005]

The above-described TFT is generally composed of a gate

electrode 72 provided on a glass substrate 71, a gate insulating film 73 which is formed so as to cover the gate electrode 72, an active layer 76 provided on the gate insulating film 73, and a source electrode 77 and a drain electrode 78 which are in contact with the active layer 76.

[0006]

A protective film 75 is provided on the active layer 76 between the source electrode 77 and the drain electrode 78. Further, the active layer 76 is in contact with the source electrode 77 and the drain electrode 78 via an ohmic contact layer 76. The source electrode 78 is coupled to a signal line 79. Further, the signal line 79 and the TFT are prevented from being directly in contact with the liquid crystal layer 82 by means of an inter-layer insulating film 84.

[0007]

In order to increase the resolution of a liquid crystal display device configured as described above, it is necessary to dispose the pixel electrode 81 and the signal line 79 as close to each other as possible for increasing the aperture ratio.

[0008]

However, when the pixel electrode 81 and the signal line 79 are brought closer together, the electric field generated therebetween increases. The increased electric field then causes a change in the alignment of liquid crystal molecules 82_1 in the liquid crystal layer 82 at a portion adjacent to the pixel electrode 81 and the signal line 79. This results in discontinuity of the alignment of the liquid crystal layer 82, which causes problems of generation of a so-called disclination line 86 and degradation of display quality.

[0009]

In order to solve the above problems, a technology in which a black matrix 85 is provided on the opposing electrode 83 at a portion where the disclination line 86 is generated for shielding the disclination line 86 has been proposed.

[0010]

This technique, however, has a problem that the display

portion which contributes to actual display is decreased by an area corresponding to the black matrix, thereby lowering the aperture ratio.

[0011]

[Problems to be Solved by the Invention]

As described above, a conventional liquid crystal display device suffers from the problem that, when the pixel electrode and the signal line are designed closer to each other so as to increase the resolution, the electric field generated therebetween is increased and this causes generation of a disclination line and degradation of the aperture ratio.

[0012]

While the above problem can be solved by shielding the declination line by the black matrix, this leads to a problem that the aperture ratio is reduced by an amount corresponding to the black matrix.

[0013]

The present invention is made in view of the above circumstances and aims to provide a liquid crystal display device in which degradation of display quality caused by a disclination line can be prevented without causing a decrease in the aperture ratio.

[0014]

[Means for Solving the Problems]

In order to achieve the above object, a liquid crystal display device of the present invention (claim 1) comprises pixel electrodes arranged in a matrix on a substrate; thin film transistors each of which serves as a switching element and is provided under each of the pixel electrodes; lines each provided under an interval between two of the pixel electrodes adjacent to each other; an opposing electrode provided above the pixel electrodes; and a liquid crystal layer which is provided between the pixel electrodes and the opposing electrode and which has a thickness greater than a distance between two of the pixel electrodes adjacent to each other.

[0015]

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Further, a liquid crystal display device of the present invention (claim 2) comprises pixel electrodes arranged in a matrix on a substrate; thin film transistors each of which serves as a switching element and is provided under each of the pixel electrodes; lines each provided under an interval between two of the pixel electrodes adjacent to each other; an opposing electrode provided above the pixel electrodes; a liquid crystal layer provided between the pixel electrodes and the opposing electrode; and an electric field concentration member provided between the lines and the opposing electrode.

[016]

The line described above may be a signal line, a gate line, or the like.

[0017]

[Effect]

According to the liquid crystal display device of the present invention (claim 1), because the distance between two adjacent pixel electrodes is smaller than the thickness of the liquid crystal layer, the electric field generated between the two adjacent pixel electrodes is greater than the electric field generated between the pixel electrode and the opposing electrode.

[0018]

With this structure, it is possible to generate and fix a disclination line in the liquid crystal layer between two adjacent pixel electrodes. Further, the line is located under the interval between the two adjacent pixel electrodes. In other words, the portion where the disclination line is fixed is a portion which originally does not contribute to display.

[0019]

Consequently, it is possible to prevent degradation of display quality caused by the disclination line without causing a decrease in the aperture ratio.

[0020]

Further, according to another liquid crystal display device of the present invention (claim 2), because the electric

field concentration member is provided between the line and the opposing electrode, even when the line and the pixel electrode is provided close to each other, the disclination line is generated in the electric field concentration member and fixed therein. In addition, as the line is located under the electric field concentration line, the portion where the disclination line is fixed is a potion which does not originally contribute to display.

[0021]

It is therefore possible to prevent degradation of display quality caused by the disclination line without causing a decrease in the aperture ratio.

[0022]

[Embodiments]

Preferred embodiments of the present invention will be described with reference to the drawings.

[0023]

Fig. 1 is a view schematically showing an active matrix liquid crystal display device according to a first embodiment of the present invention.

[0024]

In Fig. 1, numeral 11 denotes a pixel electrode, which is connected to a source electrode 8 of a TFT. Further, an opposing electrode 13 is provided on the pixel electrode 10, 11 via a liquid crystal layer 12.

[0025]

As opposed to the conventional structure, according to the present embodiment, the distance between the pixel electrodes 10 an 11 is smaller than the thickness of the liquid crystal layer 12. Specifically, the distance between the pixel electrodes 10, 11 is 4 μm and the thickness of the liquid crystal layer is 5 μm, for example.

[0026]

The above-described TFT is generally composed of a gate electrode 2 (a gate line) provided on a glass substrate 1, a gate insulating film 3 which is formed so as to cover the gate

electrode 2, an active layer 4 provided on the gate insulating film 3, and a drain electrode 7 and a source electrode 8 which are in contact with the active layer 4.

[0027]

A protective film 5 is provided on the active layer 4 between the source electrode 8 and the drain electrode 7. Further, the active layer 4 is in contact with the source electrode 8 and the drain electrode 7 via an ohmic contact layer 6. The source electrode 8 is coupled to a signal line 9. Further, the signal line 9 and the TFT are prevented from being directly in contact with the liquid crystal layer 12 by means of an inter-layer insulating film 14.

[0028]

The liquid crystal display device as described above may be manufactured as follows, for example.

[0029]

First, after depositing an MoTa alloy film at a thickness of 300nm on the glass substrate 1, the MoTa alloy film is pattered to form the gate electrode 2.

[0030]

Then, a silicon oxide film and a first silicon nitride film to be formed into the gate insulating film 3 are sequentially deposited at thickness of 350nm and 50nm, respectively, using a plasma CVD method. Subsequently, by means of the similar plasma CVD method, a first amorphous silicon film to be formed into the active layer 4 and a second silicon nitride film to be formed into the protective film 5 are sequentially deposited at thickness of 50nm and 200nm, respectively.

[0031]

After patterning the second silicon nitride film to form the protective film 5, a second n+ amorphous silicon film to be formed into the ohmic contact layer 6 is formed using a plasma CVD method. Then, the first and second amorphous silicon layers are patterned simultaneously to form an island of amorphous silicon.

[0032]

Then, after forming the signal line 9 composed of an Mo film having a thickness of 50nm and an Al film having a thickness of 300nm, a third silicon nitride film serving as the interlayer insulating film 14 is deposited at a thickness of 200nm using a plasma CVD method. Then, the drain electrode 7 and the source electrode 8 are formed. Here, the drain electrode 7, the source electrode 8, and the signal line 9 may be formed simultaneously in the same process. Further, a film made of a refractory metal such as Mo, W, Cr, or the like may be formed on the Al film.

[0033]

Then, after covering the surface of the third nitride silicon film with a fluorine polyimide film having a 1.5 µm as the interlayer insulating film 14 by spin coating, the film is cured at a temperature below the degradation temperature of amorphous silicon (300°C), at 250°C, for example. In the case of a poly silicon (p-Si) TFT, full curing at 450°C may be performed.

[0034]

Subsequently, the above-described polyimide film is etched by reactive ion etching by means of CF_4 gas to form a contact hole above the source electrode 8. Then, a polyimide film for alignment is formed on the surface to form an ITO film having a thickness of 100nm, which is then etched to form the pixel electrodes 10, 11.

[0035]

Finally, liquid crystal is injected between the opposing electrode 13 and the pixel electrodes 10 and 11 having the polyimide film for alignment formed on surface, thereby forming the liquid crystal layer 12.

[0036]

According to the liquid crystal display device of the present embodiment, because the distance between the two adjacent pixel electrodes 11 and 12 is smaller than the thickness of the liquid crystal layer 12, the electric field generated between the two adjacent pixel electrodes 11 and 12

can be made grater than the electric field generated between the pixel electrodes 11 and 12 and the opposing electrode 13. Consequently, the direction of the liquid crystal molecule 12_1 above the electrode 9 is changed due to the electric field generated between the pixel electrodes 11 and 12, whereby the disclination line 15 is generated.

[0037]

For example, in the signal line inversion driving, a voltage of 0 to 5V corresponding to a video signal voltage is applied to the pixel electrode; a voltage of -5 to 0V is applied to the adjacent pixel electrode; and a voltage of 0V, which is an intermediate voltage, is applied to the opposing electrode. Accordingly, if the distance between the pixel electrodes is smaller than the thickness of the liquid crystal layer, the difference of voltages applied to the adjacent pixel electrodes is necessarily greater than the potential difference between the opposing electrode and the pixel electrode. Further, because the electric field between the signal line or the gate electrode (gate line) and the pixel electrode is shielded by the pixel electrode, this electric field has substantially no effects on the liquid crystal layer.

[0038]

As such, it is possible to generate and fix the disclination line 15 in the liquid crystal layer 12 between the pixel electrodes 11 and 12. Further, the signal line 9 is located under the interval between the pixel electrodes 11 and 12. In other words, the portion where the disclination line 15 is fixed is a portion which does not originally contribute to display.

[0039]

Consequently, it is possible to prevent degradation of display quality caused by the disclination line 15 without causing a decrease in the aperture ratio.

[0040]

The thickness d of the liquid crystal and the distance between the pixel electrodes are preferably set as follows.

[0041]

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Because the pixel potentials are of opposite signs even if the thickness of the liquid crystal d and the distance between the pixel electrodes L are the same (d=L), the intensity of electric field is greater between the pixel electrodes, and the disclination is generated between the pixel electrodes, namely on the line. Further, as no electric field is generated when a voltage of the same value (=0) is applied to the pixel electrodes, dislincation is not generated. Thus, in order to ensure that the electric field between the pixel electrode is greater than the electric field between the opposing electrode and the pixel electrodes, it is necessary to fulfill the relationship of $L/d \leq 1$, preferably $L/d \leq 0.9$ to 0.4. The smaller value is limited by likelihood to generate short circuit between the adjacent pixel electrodes. Further, disclination is generated when the direction of alignment of liquid crystal molecules and the direction of the electric field are opposite. Therefore, as it is likely that the disclination is generated at the left end of the pixel electrodes when the liquid crystal molecules tilt toward the right direction, it is preferable to increase the overlapping portion of the left end of the pixel electrode and the line.

[0042]

Further, according to the present embodiment, the coupling capacitor between the signal line 9 and the pixel electrodes 11 and 12 is approximately 1/7 of the capacitor obtained when a nitride silicon film (typically of a thickness of 500nm) with the dielectric constant of 6.4 which is normally used is adopted, because the fluorine polyimide film serving as the interlayer insulating film has a dielectric constant of 2.8 and a thickness of 1.5 μm. Thus, according to the present embodiment, the coupling capacitor between the signal line 9 and the pixel electrodes 11 and 12 can be reduced sufficiently, whereby crosstalk can be reduced considerably. Further, the dielectric constant of the fluorine polyimide film can be selected within the range of 2 to 4.

[0043]

Further, in the case of a silicon nitride film which is typically used, the film thickness is limited to approximately 500nm because film removal is caused by stress, and the problem of covering the steps remains unsolved. According to the present embodiment, on the contrary, because a fluorine polyimide film is used, the film thickness can be increased to several µm. Specifically, as the film can be deposited to a thickness which can eliminate steps and the surface can be made flat, planarity of the alignment film on the pixel electrodes can be enhanced and rubbing can be performed uniformly, whereby image quality can be improved.

[0044]

Fig. 2 is a view schematically showing a structure of an active matrix liquid crystal display device according to a second embodiment of the present invention. Here, parts corresponding to those in the liquid crystal display device shown in Fig. 1 are designated by the same numerals and will not be described in detail.

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(54)【発明の名称】 液晶表示装置

(57)【要約】
【目的】開口率の低下を招くこと無くディスクリネーション線による表示品質の劣化を防止できるアクティブマトリクス型液晶表示装置を提供すること。
【構成】ガラス基板１上にマトリクス配列された画素電極１０，１１と、画素電極１１の下部に設けられたスイッチング素子としての薄膜トランジスタと、隣接する二つの画素電極１０，１１の間隙の下部に設けられた信号線９と、画素電極１０，１１上に設けられた対向電極１３と、画素電極１０，１１と向対電極１３との間に設けられ、厚さが隣接する二つの画素電極１０、１１間の距離よりも大きい液晶層１２とを備えている。